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PLASMA PROCESSING SYSTEM

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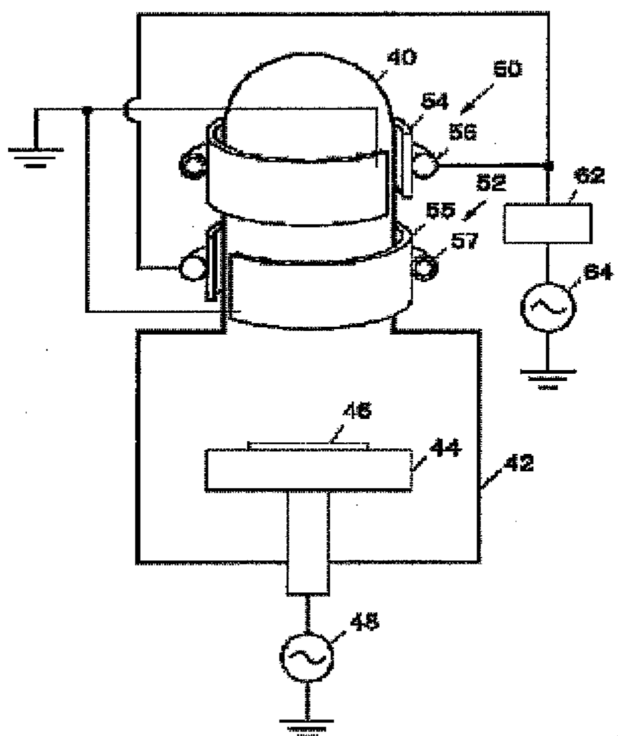
Abstract of **JP8279493**

PURPOSE: To set the ratio between the inductive coupling discharge component and capacitive coupling discharge component appropriately by disposing a pair of antenna bodies such that the induced fields are directed reversely from each other. CONSTITUTION: Two antenna bodies 50, 52 are disposed around a plasma generation chamber 40 made of quarts and fed with currents in reverse directions. Since the fields induced from the antenna bodies are weakened each other, the inductive coupling discharge component is reduced. Extent of reduction can be regulated by varying the distance between the antenna bodies 50, 52. Since the band plates 54, 55 of the antenna bodies 50, 52 are facing the plasma generation chamber 40, a planar antenna surface is provided thus increasing the area of a sheath formed closely to the inner wall of the plasma generation chamber 40. Consequently, the capacitive coupling discharge component is increased. The area of sheath depends on the width W of the band plates 54, 55.



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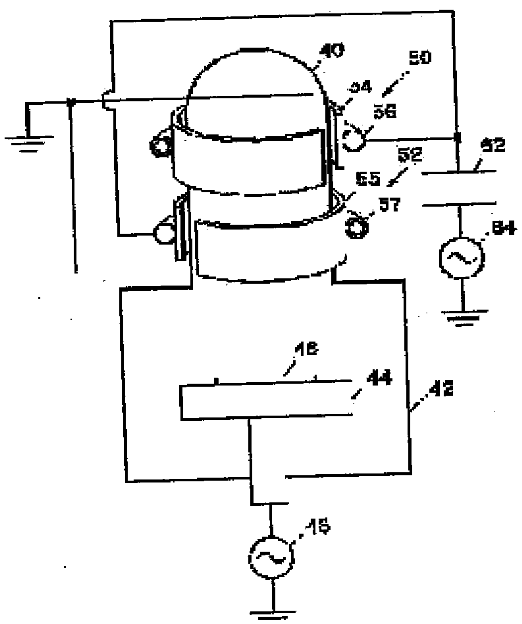
(54) PLASMA PROCESSING SYSTEM



(57)Abstract:
PURPOSE: To set the ratio between the inductive coupling discharge component and capacitive coupling discharge component appropriately by disposing a pair of antenna bodies such that the induced fields are directed reversely from each other.
CONSTITUTION: Two antenna bodies 50, 52 are disposed around a plasma generation chamber 40 made of quarts and fed with currents in reverse directions. Since the fields induced from the antenna bodies are weakened each other, the inductive coupling discharge component is reduced. Extent of reduction can be regulated by varying the distance between the antenna bodies 50, 52. Since the band plates 54, 55 of the antenna bodies 50, 52 are facing the plasma generation chamber 40, a planar antenna surface is provided thus increasing the area of a sheath formed closely to the inner wall of the plasma generation chamber 40. Consequently, the capacitive coupling discharge component is increased. The area of sheath depends on the width W of the band plates 54, 55.

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CLAIMS

[Claim(s)]
[Claim 1] In the plasma treatment equipment which arrange antenna equipment around the plasma generating room formed with the dielectric, and the interior of a plasma generating room is made to generate the plasma by passing a current to this antenna equipment, and processes a processed object Said antenna equipment is plasma treatment equipment characterized by connecting these antenna objects to a power unit so that it may have one pair of antenna objects and the magnetic field one antenna object carries out [a magnetic field] induction may become the magnetic field and hard flow of the antenna object of another side which carry out induction in the interior of a plasma generating room.
[Claim 2] Said plasma generating room is plasma treatment equipment according to claim 1 characterized by being cylindrical, and said one pair of antenna objects arranging around this plasma generating room at the shaft orientations of a plasma generating room, and being arranged.
[Claim 3] Plasma treatment equipment according to claim 2 with which the antenna pitch from the shaft-orientations mid gear of one antenna object to the shaft-orientations mid gear of the antenna object of another side is characterized by being smaller than the bore of an antenna object.
[Claim 4] Plasma treatment equipment according to claim 1 characterized by the ability to adjust said antenna pitch.
[Claim 5] Plasma treatment equipment according to claim 1 characterized by the electric supply section of one antenna object and the electric supply section of the antenna object of another side having countered across a plasma generating room.
[Claim 6] In the plasma treatment equipment which arrange antenna equipment around the plasma generating room formed with the dielectric, and the interior of a plasma generating room is made to generate the plasma by passing a current to this antenna equipment, and processes a processed object Said antenna equipment is equipped with one pair of antenna objects, and the magnetic field one antenna object carries out [a magnetic field] induction sets it inside a plasma generating room. It is plasma treatment equipment which these antenna objects are connected to the power unit, and is characterized by this band-like plate enclosing the perimeter of a plasma generating room including the band-like plate with which said antenna object meets a plasma generating room so that it may become the magnetic field and hard flow of the antenna object of another side which carry out induction.
[Claim 7] Said band-like plate is plasma treatment equipment according to claim 6 characterized by surrounding the perimeter of a plasma generating room over 1 round substantially.
[Claim 8] Plasma treatment equipment according to claim 6 characterized by the quality of the material of said plasma generating room being a quartz.
[Claim 9] Plasma treatment equipment according to claim 6 characterized by the quality of the material of said plasma generating room being an aluminum oxide.
[Claim 10] Plasma treatment equipment according to claim 6 characterized by the quality of the material of said plasma generating room being alumimium nitride.
[Claim 11] Plasma treatment equipment according to claim 6 characterized by the quality of the material of said plasma generating room being silicon nitride.
[Claim 12] Plasma treatment equipment according to claim 6 characterized by impressing a magnetic field parallel to this internal surface near the internal surface of said plasma generating room.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]

[Industrial Application] This invention relates to the plasma treatment equipment which improved the antenna equipment for generating the plasma especially about the plasma treatment equipment which performs etching and membrane formation of a semiconductor device in a vacuum.
[0002]
[Description of the Prior Art] Drawing 6 is the block diagram of conventional plasma treatment equipment equipped with the plasma generating room of an inductive-coupling mold. The coiled form antenna 12 is wound around the perimeter of the plasma generating room 10 formed with the dielectric, and this antenna 12 generates induction electric field in the plasma generating room 10 under reduced pressure. RF generator 16 is connected to the end of an antenna 12 through a matching box 14, and power is supplied by this RF generator 16. The other end of an antenna 12 is usually grounded.
[0003] The case where plasma etching of the wafer is carried out using this plasma treatment equipment is explained. In the plasma generating room 10, the processing room 18 is open for free passage, and the substrate electrode holder 20 is installed in this processing room 18. The processed wafer 22 is placed on this substrate electrode holder 20. Bias power supply 24 is connected to the substrate electrode holder 20, and it has structure which can control the incidence ion energy to a wafer 22.
[0004] Drawing 7 is the block diagram of conventional plasma treatment equipment equipped with the plasma generating room of the cathode joint mold which is a kind of a capacity-coupling mold. The processed wafer 28 is placed on a cathode 26, RF generator 30 is connected to this cathode 26, and the power for plasma production maintenance is supplied. A cathode 26 is countered, there is a counterelectrode 32 and this counterelectrode 32 is grounded through the plasma generating room 34. The plasma generating room 34 serves as the processing room in this cathode joint type of example.
[0005]
[Problem(s) to be Solved by the Invention] Since the discharge in low voltage is possible for the plasma generating room of the inductive-coupling mold of drawing 6 as compared with the plasma generating room of the capacity-coupling mold of drawing 7, when this is applied to etching, it has the advantage that good anisotropic etching is realizable. However, this inductive-coupling mold has the problem that dissociation of process gas progresses too much. This trouble is explained in detail below. Drawing 8 is the sectional view showing the electromagnetic-field condition in the plasma generating room 10 of drawing 6. If alternating current flows the coiled form antenna 12, induction of the line of magnetic force 36 is carried out, and since this line of magnetic force 36 is changed in time, the annular induction line of electric force 38 will produce it by this. This induction line of electric force 38 is produced in [whole] plasma bulk. If it is in such a situation and an electron exercises the inside of the plasma, it is accelerated in this induction electric field, and collides the gas inside the plasma generating room 10, and many times, and ion will be generated or dissociation and excitation of process gas will be caused. Consequently, process gas will be dissociated too much by even the configuration atom or the small atomic group of an atomic number. Thus, if dissociation of process gas progresses too much, depending on a process, it may be inconvenient. For example, to carry out plasma etching of SiO2, the radical of an in-between dissociation condition like CF2 or CF3 is required, but if dissociation of process gas progresses too much, sufficient selection ratio for Si will not be obtained, without seldom obtaining these radicals.
[0006] By the way, in the inductive-coupling mold of drawing 6, if the current supplied to the coiled form antenna 12 is decreased, ionization degree can be lessened. However, since the induction electric field which accelerate an electron exist in [whole] plasma bulk, dissociation of process gas advances with the whole plasma bulk. Consequently, compared with a capacity-coupling mold, the degree of dissociation of process gas will become high too. Thus, with plasma treatment equipment equipped with the plasma generating room of an inductive-coupling mold, sufficient selection ratio cannot be obtained to Substrate Si only by lessening antenna current, for example in etching of SiO2.
[0007] On the other hand, in the capacity-coupling mold of drawing 7, the ion accelerated mainly in the fall of potential part (the so-called sheath) of the front face of a cathode 26 collides with a cathode 26, an electron is emitted by gamma operation in that case, and plasma production maintenance is made with this electron. Usually, the thickness of this sheath is about 10mm from hundreds of micrometers. Since generation of ion and a radical is limited in this thin sheath with which an electron receives acceleration, the count to which an electron collides with process gas does not increase so much, and high order dissociation of process gas does not progress as a result. Therefore, for example in etching of SiO2, the plasma containing many radicals of the in-between dissociation condition of CF2 or CF3 grade can be acquired, and the high selection ratio for Si can be

obtained as a result. However, in comparison with the plasma generating room of an inductive-coupling mold, working pressure is high, therefore is inferior about the capacity of anisotropic etching, and etching of a detailed pattern 0.25 micrometers or less has the problem that it cannot do.
[0008] It was made in order that this invention might solve the above conventional troubles, and the purpose is in offering the plasma treatment equipment which combines the discharge component of inductive-coupling nature, and the discharge component of capacity-coupling nature. Another purpose of this invention is to offer the plasma treatment equipment which can adjust the rate of the discharge component of inductive-coupling nature, and the discharge component of capacity-coupling nature.
[0009]
[Means for Solving the Problem] The plasma treatment equipment of this invention has the description in the antenna equipment formed in the perimeter of a plasma generating room. Namely, this invention arranges antenna equipment around the plasma generating room formed with the dielectric. In the plasma treatment equipment which the interior of a plasma generating room is made to generate the plasma, and processes a processed object by passing a current to this antenna equipment Said antenna equipment is equipped with one pair of antenna objects, and these antenna objects are connected to the power unit so that the magnetic field one antenna object carries out [a magnetic field] induction may become the magnetic field and hard flow of the antenna object of another side which carry out induction in the interior of a plasma generating room.
[0010] This invention is theoretically applicable to any plasma treatment equipments, if a processed object is processed using the plasma. If the example of representation of applicable plasma treatment equipment is given, there are plasma etching, ashing, plasma surface treatment, plasma CVD, etc.
[0011] If a typical configuration is described, the plasma generating room is cylindrical, and around this plasma generating room, one pair of antenna objects will arrange to the shaft orientations of a plasma generating room, and will be arranged. In this case, it is effective to make it smaller than the bore of an antenna object, the distance, i.e., the antenna pitch, from the shaft-orientations mid gear of one antenna object to the shaft-orientations mid gear of the antenna object of another side. And as for an antenna pitch, it is desirable to make accommodation possible. Moreover, it is desirable to arrange so that the electric supply section of one antenna object and the electric supply section of the antenna object of another side may counter across a plasma generating room.
[0012] If the desirable configuration of an antenna object is explained, as the band-like plate which meets a plasma generating room is included, this band-like plate encloses the perimeter of a plasma generating room. And this band-like plate encloses the perimeter of a plasma generating room over 1 round substantially.
[0013] As for the quality of the material of a plasma generating room, it is desirable to choose the optimal quality of the material according to the process carried out with plasma treatment equipment. As for the quality of the material of a plasma generating room, in the case of the process which oxygen may mix, it is desirable to make it a quartz. When using the process gas of a fluorine system, an aluminum oxide is desirable, and alumimium nitride is desirable to remove the effect of oxygen completely. Silicon nitride is desirable when the effect of aluminum also wants to also remove the effect of oxygen.
[0014] Moreover, in order that a plasma generating room may mitigate the effect by which sputtering is carried out, a magnetic field parallel to this internal surface may be impressed near the internal surface of a plasma generating room.
[0015]
[Function] One pair of antenna objects arranged so that the magnetic field of hard flow may be generated mutually weaken each other induced magnetic field mutually, and induction electric field become weaker as the result. This means that the discharge component of inductive-coupling nature can weaken. A denial operation of the discharge component of this inductive-coupling nature can be adjusted by adjusting an antenna pitch. Furthermore, if the band-like plate of an antenna object is made to meet a plasma generating room, the sheath area near the internal surface of a plasma generating room can be increased. This means that the discharge component of capacity-coupling nature increases. The discharge component of this capacity-coupling nature can be adjusted by adjusting the width of face of a band-like plate. If the rate of the discharge component of inductive-coupling nature and capacity-coupling nature is optimized, for example in plasma etching of SiO_2, etching which combines high-speed etching and the low voltage discharge property which are the advantage of the plasma treatment equipment of an inductive-coupling mold, and the high selectivity over the substrate Si which is the advantage of the plasma treatment equipment of a capacity-coupling mold will be attained.
[0016]

[Example] Drawing 1 is the block diagram of the plasma treatment equipment of one example of this invention. The upper plasma generating room 40 and the downward processing room 42 are open for free passage, and the processed wafer 46 is placed on the substrate electrode holder 44 in the processing room 42. The substrate electrode holder 44 is connected to bias power supply 48.

[0017] The plasma generating room 40 made from a quartz is cylindrical, and the upper limit is the outline spherical surface-like. Two antenna objects 50 and 52 are arranged around this plasma generating room 40. The up antenna object 50 becomes the external surface of the strip 54 of the shape of radii which meets the plasma generating room 40, and this strip 54 from the water-cooled pipe 56 of the shape of radii by which low attachment was carried out. This strip 54 and the water-cooled pipe 56 are formed with the conductor. As shown in the top view of drawing 2 , the strip 54 and the water-cooled pipe 56 enclose the plasma generating room 40 over about 1 round, and have run out by 1 place 58 on a periphery. Therefore, this up antenna object 50 is the so-called 1 turn antenna. Cooling water flows inside the water-cooled pipe 56. The lower antenna object 52 also consists of the strip 55 and the water-cooled pipe 57 of the same configuration as the up antenna object 50.

[0018] Drawing 2 is the top view showing the configuration and arrangement condition of two antenna objects. The up antenna object 50 and the lower antenna object 52 are arranged so that the cutting part may serve as an opposition mutually. That is, with the up antenna object 50, the cutting part 58 is located on right-hand side in drawing 2 , and the cutting part 60 is located on left-hand side with the lower antenna object 52. With the up antenna object 50, the water-cooled pipe 56 by the side of the end of the cutting part 58 is connected to RF generator 64 through the matching box 62. The strip 54 by the side of the other end of the cutting part 58 is grounded. Moreover, with the lower antenna object 52, the water-cooled pipe 57 by the side of the end of the cutting part 60 is connected to RF generator 64 through the matching box 62, and the strip 55 by the side of the other end is grounded. There are the entries 66 and 68 and outlets 67 and 69 of cooling water in the water-cooled pipes 56 and 57.

[0019] In this example, as shown in drawing 2 , the cutting part 58 of the up antenna object 50 and the cutting part 60 of the lower antenna object 52 serve as the electric supply section, and across the plasma generating room, these electric supply sections counter and are arranged. By the way, although a plasma consistency becomes high locally near the electric supply section since electric field strong in the electric supply section of an antenna object are generated, relaxation distribution of a plasma consistency becoming high locally is carried out by arranging the two electric supply sections to the opposite side mutually like this example. The thereby more uniform plasma can be acquired.

[0020] Two antenna objects 50 and 52, RF generators 64, and a ground are connected so that the direction of the current which flows on the antenna objects 50 and 52 may become the reverse sense mutually. For example, in drawing 2 , when it sees from a top like an arrow head 70 on the up antenna object 50 at a certain moment and a current flows clockwise, on the lower antenna object 52, a current flows counterclockwise like an arrow head 71.

[0021] Next, how to etch SiO2 using the plasma treatment equipment shown in drawing 1 is explained. First, in drawing 1 , the processed wafer 46 is carried and placed on the substrate electrode holder 44, and the plasma generating room 40 and the processing room 42 are exhausted by the exhaust air system (not shown). Next, the processing room 42 is supplied, carrying out control of flow of the process gas of CHF3 or C4F8 grade through a massflow controller according to a gas supply system (not shown). Next, the variable orifice between the processing room 42 and an exhaust air system is controlled by the pressure-control controller, and the pressure of the processing room 42 is maintained at the range of 1 - 100mTorr. Next, power is supplied to two antenna objects 50 and 52 through a matching box 62 from RF generator 64. In order to control the incidence energy of ion, power is supplied to the substrate electrode holder 44 from bias power supply (RF generator) 48 at coincidence. The plasma occurs inside the plasma generating room 40, and process gas is dissociated to the radical of CF2 or CF3 grade, and is diffused toward the processing room 42. SiO2 on a wafer 46 is etched by this radical.

[0022] Next, the mechanism which can control the rate of the discharge component of inductive-coupling nature and the discharge component of capacity-coupling nature by the plasma treatment equipment of drawing 1 is explained. Drawing 3 is the explanatory view having shown the condition of the electromagnetic field inside the plasma generating room 40. On the up antenna object 50, the current of a clockwise rotation as shown in the arrow head 70 of drawing 2 at a certain moment is flowing, and it is assumed on it that this current is increasing with time amount. Then, the downward induction line of magnetic force 72 is generated according to this current.

Moreover, since the flowing current is increasing the up antenna object 50, the flux density of the induction line of magnetic force 72 also increases, and the induction line of electric force 74 is generated in the direction (seeing from a top counterclockwise rotation) which prevents the time variation. On the other hand, since the up antenna object 50 and the current of the reverse sense are flowing on the lower antenna object 52, with this lower antenna object 52, it regards as the upward induction line of magnetic force 73 from a top, and the clockwise induction line of electric force 75 is generated.

[0023] By the way, if the up antenna object 50 and the lower antenna object 52 are approaching to some extent, each induced magnetic field to generate will be mutually weakened for the reverse sense, consequently net induction electric fields will decrease in number. Thereby, the degree of inductive-coupling nature decreases. And the degree which negates an induction magnetic field mutually and suits can be adjusted by changing the distance between two antenna objects 50 and 52. In addition, in the interface 76 between the up antenna object 50 and the lower antenna object 52, it negates completely each other's induced magnetic field component which crosses this field perpendicularly, and it serves as zero.

[0024] On the other hand, since the strips 54 and 55 have met the plasma generating room 40, the antenna objects 50 and 52 serve as a field-like antenna side, and can take a large area of the sheaths 78 and 79 formed near the internal surface of the plasma generating room 40 as compared with the coil of the conventional circular cross section. Thereby, the degree of capacity-coupling nature increases. The area of sheaths 78 and 79 can be optimized by adjusting the width of face W of strips 54 and 55.

[0025] Drawing 4 is a graph which shows the direction distribution of a path of the induced magnetic field reinforcement of the plasma generating interior of a room. An axis of ordinate is the reinforcement of the induced magnetic field component which crosses this longitudinal plane of symmetry 80 in the shaft-orientations longitudinal plane of symmetry 80 (refer to drawing 3) of the up antenna object 50, and an axis of abscissa is the distance from a chamber (plasma generating room) core. In this longitudinal plane of symmetry 80, as for the magnetic field as for which the up antenna object 50 carries out induction, the shaft-orientations component of an induced magnetic field serves as max. It calculates and asks for this graph on the conditions of d= 20-100mm of pitches of t= 1mm in the bore of D= 100mm of an antenna object, width of face of W= 10mm of an antenna object, and thickness of an antenna object, coil current = direct-current 10A, and two antenna objects. Although this graph is calculated in the longitudinal plane of symmetry 80 of the up antenna object 50, it turns into the same graph also in the longitudinal plane of symmetry of the lower antenna object 52.

[0026] If the antenna pitch d is decreased so that this graph may show, and two antenna objects are brought close namely,, induced magnetic field reinforcement decreases. Especially the induced magnetic field reinforcement in the core (location whose distance from a chamber core is 0mm) of a plasma generating room decreases greatly. And by the place where the induction rule of faraday teaches induction electric field strength, since it is proportional to the product of induced magnetic field reinforcement and the degree of the time amount change, if the induced magnetic field reinforcement which crosses perpendicularly the flat surface made into a problem is [in / the electromagnetic-field system currently changed by constant frequency] small, induction electric field will also become small.

[0027] Drawing 4 has also shown the example of count when establishing only one antenna object as "1 A coil." The curve with the curve bottom of this "1 Coil" is an example of count when setting the pitch d of two antenna objects to 100mm (that is, the antenna pitch d is equal to the bore D of an antenna object). Thus, since the curve of the induced magnetic field reinforcement at the time of one coil and the curve of the induced magnetic field reinforcement at the time of d= 100mm are approaching very much, even if they establish two antenna objects, when the antenna pitch is made larger than the bore of an antenna object, by establishing two antenna objects shows that the effectiveness of reducing induced magnetic field reinforcement is hardly expectable. That is, if two antenna objects are detached too much mutually, most interactions to expect will be lost. Therefore, an antenna pitch needs to make it smaller than the bore of an antenna object.

[0028] As explained above, in drawing 3 , by adjusting the antenna pitch d, the degree of the plasma state of inductive-coupling nature can be controlled by this example, and the degree of the plasma state of capacity-coupling nature can be controlled by it by adjusting the antenna width of face W by one side. Thereby, in required plasma etching, it becomes possible to reconcile high-speed etching which is the advantage of inductive-coupling nature, and the high selection ratio to the substrate which is the advantage of capacity-coupling nature of etchant of an in-between dissociation condition like etching of SiO_2. That is, when the antenna pitch d is enlarged and antenna width of face W is made small, the inductive-coupling nature of the plasma state becomes dominance

from capacity-coupling nature. In this condition, too much dissociation of process gas can progress and high-speed etching and a low voltage discharge property can be acquired. However, the high selection ratio to Substrate Si cannot be obtained. On the other hand, when the antenna core face to face dimension d is made small and antenna width of face W is enlarged, the capacity-coupling nature of the plasma state becomes dominance from inductive-coupling nature. Although the plasma which was rich in the CFx radical of an in-between dissociation condition can be acquired in this condition, there is a problem in respect of an etch rate and working pressure. Then, etching which combines high-speed etching and a low voltage discharge property, and the high selectivity over Substrate Si is attained by adjusting suitably the antenna pitch d and the antenna width of face W.

[0029] Next, the quality of the material of a plasma generating room is explained. An increment of the discharge component of capacity-coupling nature increases the degree which ion collides with the internal surface of a plasma generating room, and carries out sputtering of this. This means that the quality-of-the-material component of a plasma generating room mixes into a plasma ambient atmosphere. Therefore, according to the process, the quality of the material of a plasma generating room must be appropriately chosen so that the process carried out with plasma treatment equipment may seldom be affected, even if such mixing arises.

[0030] For example, in the process which uses oxygen for a subject as process gas or a process from which mixing of oxygen does not pose a problem, i.e., a multilayer-resist process, ashing, the after-treatment process of SiO2, etc., it is desirable to consider as the plasma generating room made from a quartz. The plasma generating room made from this quartz is excellent in fields, such as thermal shock resistance, a high grade (there is little mixing of an impurity), and a low price.

[0031] Moreover, when using the process gas of a fluorine system, the plasma generating room made from an aluminum oxide is desirable. For example, a usual alumina (aluminum 2O3) and a usual polycrystal alumina (translucent alumina) can be used. In this case, since this fluoride is a non-volatile even if aluminum mixes into the plasma and the fluoride of aluminum is made, effect of oxygen can be lessened as compared with the case where a quartz is used. It is desirable to use alumimium nitride (AlN) as the quality of the material of a plasma generating room to remove the effect of oxygen completely.

[0032] In order not to allow the effect of oxygen, either and to remove bad influences, such as residue and doping of the impurity to a wafer, when mixing of an aluminum atom or its compound is not allowed, either, it is desirable to use silicon nitride (SiN) as the quality of the material of a plasma generating room.

[0033] Moreover, it is effective to impress a magnetic field (for example, shaft-orientations magnetic field) parallel to an internal surface to the sheath part near the internal surface of a plasma generating room from the exterior as an approach a plasma generating room mitigates the effect by which sputtering is carried out. Drawing 5 is an example which impresses such an external magnetic field. That is, the steady external magnetic field 82 is generated by arranging one pair of magnetic field generating coils 84 around a plasma generating room, and passing a direct current in this coil 84. This external magnetic field 82 turns into a magnetic field of shaft orientations substantially in the place of sheaths 78 and 79. Although the internal surface of the plasma generating room formed with the dielectric serves as floating potential to the bulk plasma, if the above external magnetic fields 82 are impressed here, since the trap of the electron is carried out to this external magnetic field 82, required sending-back potential will become small (the electric field near the internal surface of a plasma generating room serve as negative potential to the plasma, and this negative potential is called sending-back potential for the potential which sends back an electron from a wall surface). Consequently, the incidence ion energy to the internal surface of a plasma generating room decreases, and sputtering of an internal surface decreases. Moreover, since diffusion of the plasma is controlled by this external magnetic field, a plasma consistency increases, and an etch rate improves as that result. in this example, by making the strength of the steady external magnetic field 82 of the place of sheaths 78 and 79 into about 50 gauss or more, and carrying out like this, it is markedly alike from the fluctuation magnetic field (about 6 gauss) which the antenna of the place of sheaths 78 and 79 generates, and there is effectiveness which controls sputtering of an internal surface.

[0034] This invention is effective even if they constitute each of an antenna object in the example explained so far with the coiled form antenna object which consists of two or more turns, although two antenna objects are used as 1 turn antenna, respectively.

[0035]

[Effect of the Invention] Since the magnetic field one pair of antenna objects carry out [a magnetic field] induction becomes the reverse sense mutually according to this invention, the discharge component of inductive-coupling

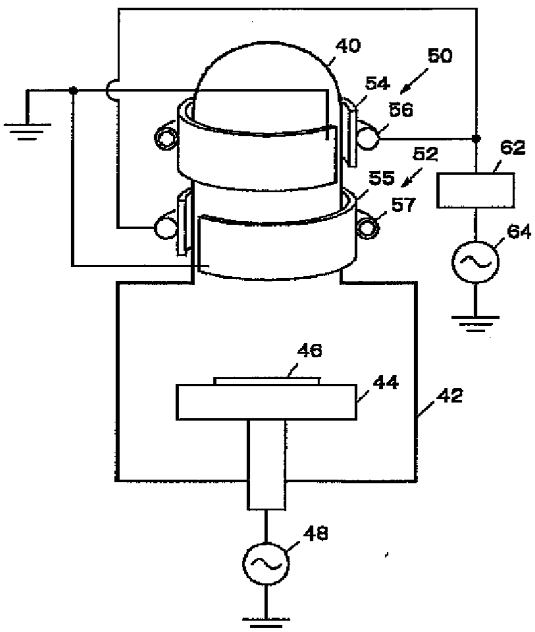
nature can decrease and too much dissociation of process gas can be prevented. If the distance between antennas is adjusted, a denial operation of a magnetic field can be adjusted and the degree of the discharge component of inductive-coupling nature can be adjusted. Moreover, if the width of face of an antenna object is adjusted, the sheath area near the internal surface of a plasma generating room can be adjusted, and the discharge component of capacity-coupling nature can be adjusted. If the rate of the discharge component of inductive-coupling nature and capacity-coupling nature is optimized, for example in plasma etching of SiO2, etching which combines high-speed etching, a low voltage discharge property, and the high selectivity over Substrate Si will be attained.

DESCRIPTION OF DRAWINGS

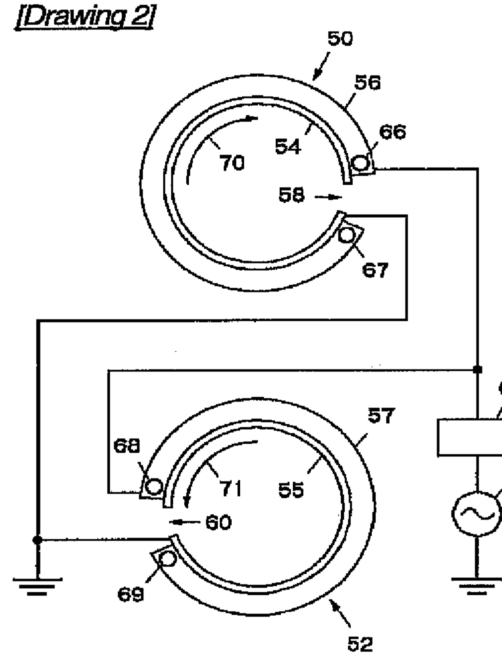
[Brief Description of the Drawings]
[Drawing 1] It is the block diagram of one example of this invention.
[Drawing 2] It is the top view showing the arrangement condition of an antenna object.
[Drawing 3] It is the explanatory view having shown the electromagnetic field of the plasma generating interior of a room.
[Drawing 4] It is the graph which shows the direction distribution of a path of the induced magnetic field reinforcement of the plasma generating interior of a room.
[Drawing 5] It is the explanatory view of the example which impresses an external magnetic field.
[Drawing 6] It is the block diagram of the conventional plasma treatment equipment of an inductive-coupling mold.
[Drawing 7] It is the block diagram of the conventional plasma treatment equipment of a capacity-coupling mold.
[Drawing 8] It is the sectional view showing the electromagnetic field of the plasma generating interior of a room of the conventional equipment of drawing 6 .
[Description of Notations]
40 Plasma Generating Room
42 Processing Room
44 Substrate Electrode Holder
46 Wafer
50 Up Antenna Object
52 Lower Antenna Object
54 55 Strip
56 57 Water-cooled pipe
64 RF Generator

DRAWINGS

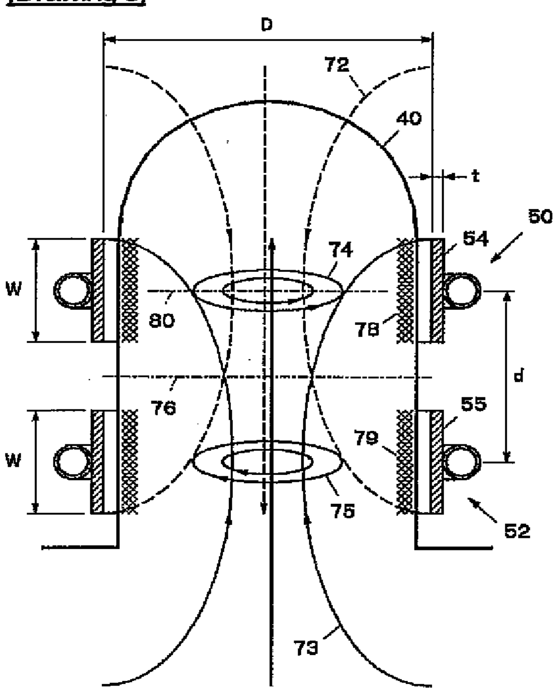
[Drawing 1]



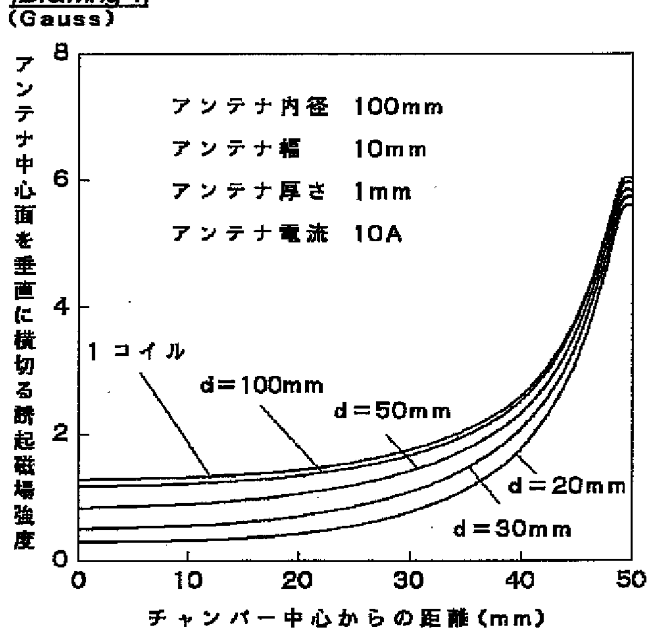
[Drawing 2]



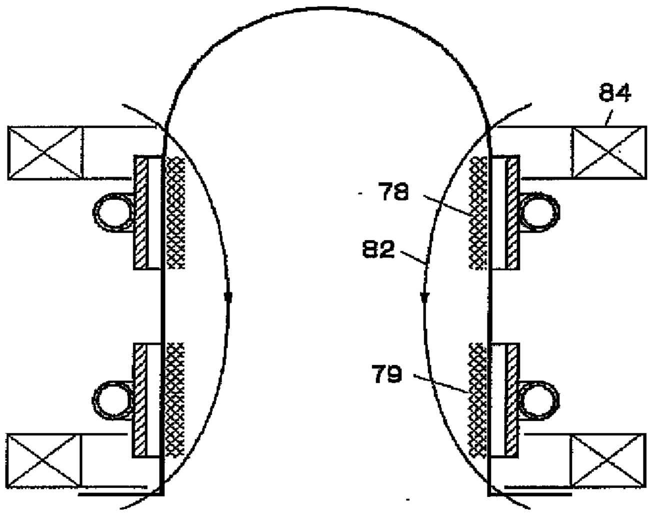
[Drawing 3]



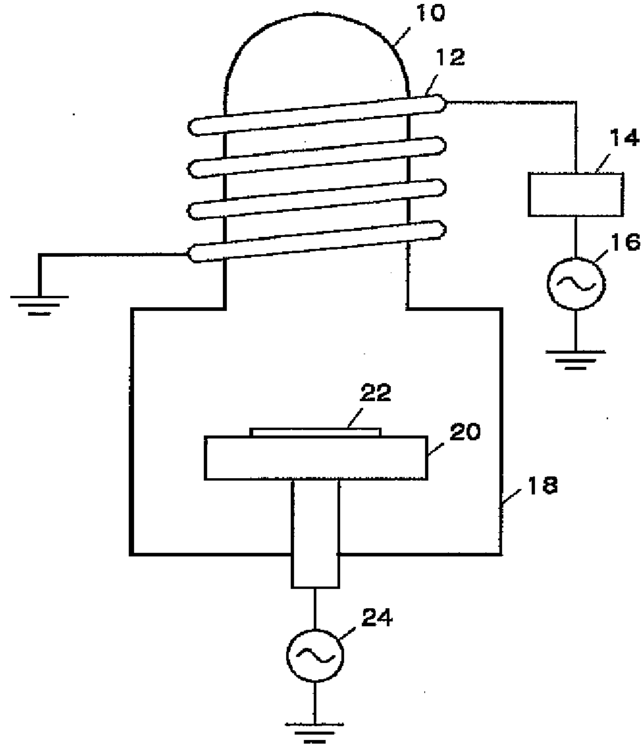
[Drawing 4]



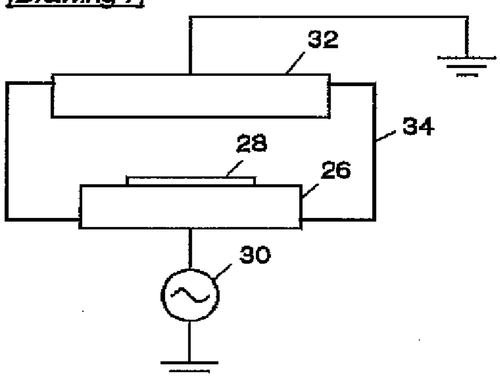
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Drawing 8]